EFFICIENT USE OF WOOD AS FUEL IN DOMESTIC APPLICATIONS

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Abstract
In many rural and urban areas of the developing countries, the extensive use of fuel wood leads to deforestation with consequent environmental problems. To address this problem, the efficient use of wood as fuel in domestic applications, could be a viable option. This calls for the design and construction of fuel-efficient wood stoves. An example of this is the fireclay stove. The device enables the efficient and effective utilization of the fuel wood by shielding the fireflame from the effect of wind and hence direct the heat energy generated to the pot base for maximum utilization.

A comparative performance evaluation test was carried out on the designed and constructed fireclay stove against a metallic fuel wood stove in terms of the fuelwood consumption and cooking time. The results showed that it took the fireclay stove and the metallic stove an average of 31 minutes and 46 minutes to cook the same quantity of 3kg of rice. Similarly the quantities of fuelwood consumed, using the fireclay and the metallic stoves were 48% and 70% of the same quantity of fuelwood used for the test respectively.

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1.0 Introduction

A major cause of deforestation in developing countries is the felling of trees for fuelwood, which is the most important source of domestic energy. The other fuel sources in domestic applications are charcoal (which is also obtained from the felling of trees) and agricultural waste products such as straw, maize cobs and rice husk. The preference for fuelwood is due to its low cost and ready availability. The demand for fuelwood places a lot of presssure on the forest and the environment in general [1]. For example, in the last 100 years, the Nigerian environment has been deteriorating at an alarming rate with adverse effect on human, wildlife and livestock and on economic activities of the country.

According to Enabor [2], the estimated rate of deforestation in Nigeria was put at 286,000 ha per annum. Also according to Asaton-Jones [3], Nigeria has already lost 90% of its forests, the economic cost of which is estimated at 20 percent of the country's GNP annually.

Large quantities of fuelwood are used in cooking on an open fire surrounded by three large stones on which cooking pots are balanced. The three stones stove uses fuelwood inefficiently and gives up a lot of smoke [4]. The amount of fuelwood needed in traditional three stone stove can be reduced by shielding the fire flame from wind. Alteration in this three stone stove design can achieve greater efficiency. The challenge of improving this traditional stove had been taken up by the development agency Intermediate Technology (IT) [4], who are working in the developing countries. Two of its most successful programmes are charcoal stove project in urban Kenya and efficient use of fuelwood in Sri Lanka.

This improved charcoal stove is very popular among the women folk in Kenya and is popularly called Jiko. This "Jiko" is made of thin sheet metal. It is low cost but inefficient because most of the heat is lost through the thin metal. It is also unsafe when the metal becomes very hot and hence is not stable. The jiko becomes unstable under high temperature like metalic burning stove. Its metal oxidises very rapidly, thereby making the stove to collapse. This corrosion does not allow the metallic jiko to last long before replacement is needed.

However the traditional jiko is now being replaced by ceramic which was adapted from a mix of baked clay and rice husk ash. This new ceramic jiko is more stable than the former jiko stove. However the cost is about twice as much as the traditional jiko. In Sri Lanka, the improved fuelwood stove is called "Anagi". This anagi was designed such that maximum heat is directed to the pots. The design made provision which can enable a number of pots to be used at the same time. The most common one is the two cylinder type, on which the cooking pots are connected by tunnel enabling two pots to be used at the same time.

Like in other developing countries, fuelwood is the most utilised energy for cooking in Nigeria when the entire populace is considered[5]. Surveys in Sokoto carried out in 1997, showed that people are willing to change from the traditional method of cooking by tripod stove, as a way of alleviating the fuelwood crisis. Some were interviewed that expressed eagerness to see the successful development of the clay stove[6] This is because in Nigeria, Omoluabi [7], estimated the demand for fuelwood at 58.9 million cubic metres in 1987 and this is expected to be on the increase due to increasing population and the shift of urban dwellers to the use of fuelwood due to the soaring prices and unavailability of alternative sources of energy. This translates to greater rate of deforestation in the near future. For example, in developing countries, fuelwood accounts for about 85% of the wood consumed while it accounts for 75% of total energy consumed in poor countries of the world [8].
However, fuelwood would continue to be the dominant domestic energy source in Nigeria with the current fuelwood consumption estimated at 79 million m3 per annum [1]. In recognition of the fact that the fuelwood for sometime will continue to be the dominant energy source, concerted efforts are required to develop energy-efficient fuelwood stoves.

The quantities of fuelwood consumed by the traditional stone and metallic stoves are enormous. Also these stoves contribute greatly to the pollution of air through uncontrolled release of carbon monoxide into the atmosphere. If fireclay can be used in designing traditional stoves, it can greatly minimize heat loss and ensure that the maximum amount of heat is directed to the cooking pot thus reducing the amount of fuelwood consumed.

Therefore, the aim of the present study is to design and construct fireclay stove and compare its performance with the traditional metallic stove, in term of efficiency of fuelwood utilization. This has the potential of reducing the rate of deforestation and land degradation.

2.0 Material and Methods

The clay was collected from Pulka in Gwoza local government area of Borno state. Recently, Inegbenebor et al [9] in their studies of chemical analysis of some clay deposits for refractory production reported that Pulka clay could be classified into the group of low-melting semi-acid fireclay.The objective of any particular design and construction dealing with the manufacture of product is to produce component that will adequately perform a designated task. The choice of low-melting semi-acid fireclay was dictated by its properties [9]. Unlike the traditional or metallic stove, which failed due to corrosion, the proposed fireclay stove has the advantage of resisting corrosion, oxidation and erosion when kneaded and heated.The design of the fireclay stove was based on the task of cooking a specified quantity of food stuff. The dimensions of the pot and weight of the pot and its contents were also used for establishing the stress acting on the fireclay stove. These data include the weight exerted by the pot and its contents on the fireclay stove as well as maximum stresses on the various members of the fireclay stove. The details of the design and construction are described elsewhere [10, 11]. The isometre diagram of the fireclay stove is shown in Fig. 1.

2.1 Performance Evaluation Procedure

Performance evaluation was done on the designed and constructed fireclay stove and the metallic stove. The same quantities of firewood of 1.8, 1.6, 1.5, 1.4 and 1.2 kg. Were weighed separately, for the five experiments on the two stoves. Three kilogrammes of rice put into each of two aluminum pots and the pots placed on the two stoves. The firewood was ignited, with the help of the same quanity of kerosine spinkled on the firewood in each of the stoves. Then the stop watch was activated, the time taken for the cooking of the 3kg of rice by each of the stoves was noted. The experiment was repeated on each quantity of firewood. The results obtained were used in a comparative performance evaluation test for the two stoves in terms of the fuelwood consumption and the time required to cook the 3kg of rice.

3.0 Results and Discussion

The test results of the comparative performance evaluation are presented in Table 1. The test results show that it takes the fireclay stove and the metallic stove an average of 31 minutes and 46 minutes to

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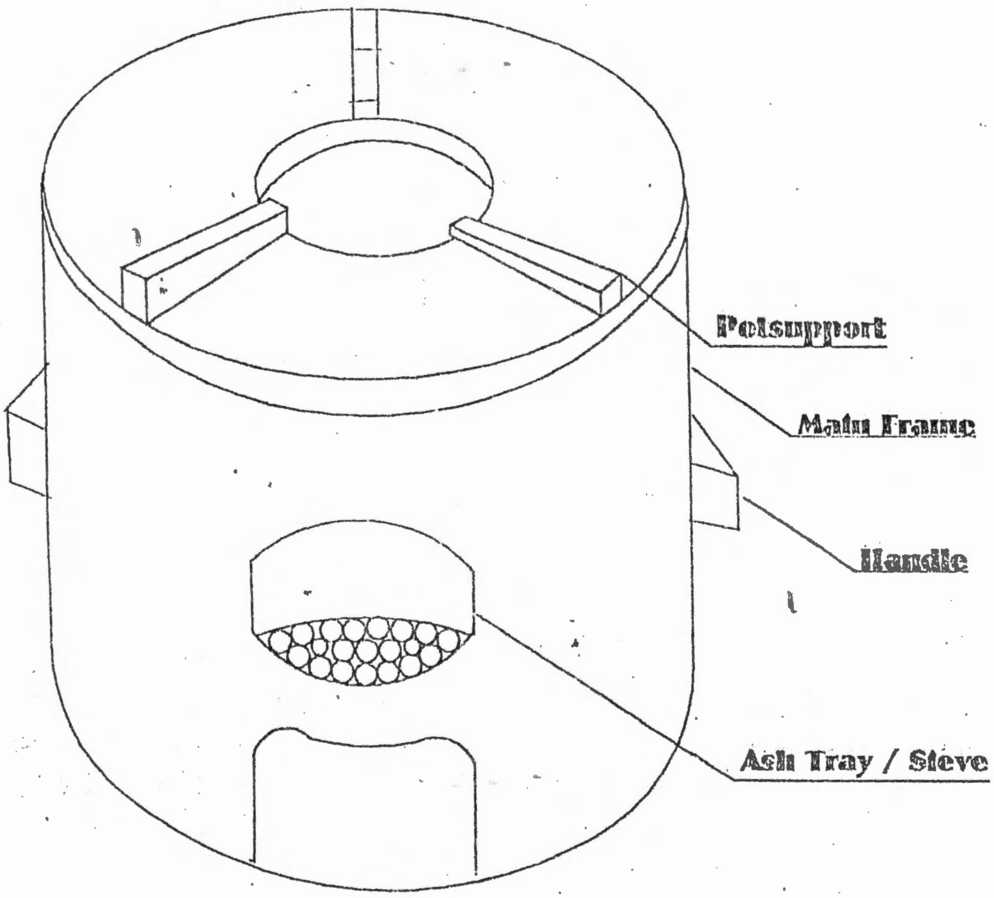

Fig. 1: An Isometric View of Fire Clay Stove

cook the same quantity of 3kg of rice. The average 31 minutes required for cooking 3kg of rice by the fireclay stove, was due to greater concentration of heat energy for cooking by the fireclay stove due to less wind interference of the flame as opposed to the metallic stove in which unshielded flame is frequently diverted from the cooking pot base, resulting in greater fuelwood consumption.

The results also showed that the quantity of fuelwood consumed using the fireclay stove in cooking three kilogram of rice was 48% of the average of fuelwood consumed. While the traditional metallic stove consumed 70% of the average of fuelwood consumed. These results are in agreement with the findings of Papka[1], which stated that energy efficient stoves could reduce fuelwood consumtion by between 40-60%.

4.0 Conclusions

As it was pointed out in the aim of this work, efficient fuelwood burning stoves are required to reduce the quantity of fuelwood consumption. The fireclay stove reported in this paper appears to have served this purpose. Therefore the following conclusions can be deduced from the work.

(1) The results of this work shows that use of the fireclay stove instead of the traditional or metallic stoves will reduce the quantity of fuelwood consumption. Therefore, when fireclay stove is used, it will help to control deforestation as less quantity of fuelwood will be utilized.

(2) It reduces the labour in cooking through efficient utilisation of fuelwood and hence less time will be required to cook.

(3) Also the fireclay stove will reduce environmental pollution in view of its characteristic lower smoke emission.

Table 1: Fuelwood consumption in Cooking 3kg of Rice on the two stoves.

	Fireclay Stove				Metallic Stove			
Type of Food Item (kg)	Quantity Fuelwood supplied used (kg)	Fuelwood consumed (kg)	Percentage of Fuelwood consumed (%)	Cooking time (minutes)	Quantity of fuel wood supplied (kg)	Fuelwood Consumed (kg)	Percentage of fuelwood consumed (%)	Cooling time (minutes)
3kg of rice	1.8	0.72	40	31.90	1.8	1.06	59	46.10
3kg of rice	1.6	0.69	43	29.10	1.6	1.15	72	47.00
3kg of rice	1.5	0.75	50	33.00	1.5	1.02	68	45.60
3kg of rice	1.4	0.70	50	30.30	1.4	1.05	75	45.90
3kg of rice	1.2	0.67	56	28.60	1.2	0.94	78	45.40
Average			48	31			70	46.00

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